

**IMPLEMENTING ARRANGEMENT**  
**BETWEEN**  
**THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)**  
**OF THE UNITED STATES OF AMERICA**  
**AND**  
**THE INDIAN SPACE RESEARCH ORGANISATION (ISRO)**  
**OF INDIA**  
**FOR COOPERATION ON**  
**GLOBAL PRECIPITATION MEASUREMENT AND MEGHA-TROPIQUES**

## **TABLE OF CONTENTS**

**PREAMBLE**

**ARTICLE 1 -- PURPOSE OF COOPERATION**

**ARTICLE 2 -- DEFINITIONS**

**ARTICLE 3 -- NASA RESPONSIBILITIES**

**ARTICLE 4 -- ISRO RESPONSIBILITIES**

**ARTICLE 5 -- GPM GOVERNANCE**

**ARTICLE 6 -- SCIENTIFIC INVESTIGATIONS**

**ARTICLE 7 -- POINTS OF CONTACT**

**ARTICLE 8 -- DATA DISTRIBUTION**

**ARTICLE 9 -- OWNERSHIP OF EQUIPMENT**

**ARTICLE 10 -- RELATIONSHIP TO THE FRAMEWORK AGREEMENT**

**ARTICLE 11 -- AMENDMENTS**

**ARTICLE 12 -- ENTRY INTO FORCE AND DURATION**

## **PREAMBLE**

The National Aeronautics and Space Administration of the United States of America (hereinafter referred to as "NASA") and the Indian Space Research Organisation (hereinafter referred to as "ISRO"), (and together hereinafter referred to as the "Parties"):

Acknowledging that in 2004, ISRO and the Centre National d'Etudes Spatiales of France (CNES) signed a Memorandum of Understanding for cooperation on the Megha-Tropiques mission;

Desiring to engage in scientific and ground validation data exchanges and related activities associated with NASA's Global Precipitation Measurement (GPM) mission and the ISRO-CNES Megha-Tropiques mission;

Recalling the terms of the Framework Agreement between the National Aeronautics and Space Administration and Indian Space Research Organisation for Cooperative Activities in the Exploration and Use of Outer Space for Peaceful Purposes, signed on February 1, 2008 (hereinafter referred to as the "Framework Agreement");

Acknowledging that NASA and CNES intend to negotiate a separate agreement to address cooperation involving GPM and Megha-Tropiques cooperation; and

Acknowledging that in 2009, NASA and the Japan Aerospace Exploration Agency (JAXA) signed a Memorandum of Understanding for cooperation on GPM;

Have reached the following arrangement:

## **ARTICLE 1 PURPOSE OF COOPERATION**

The purpose of this Implementing Arrangement is to set forth the respective responsibilities of the Parties and the terms and conditions under which they shall conduct the cooperation involving GPM and Megha-Tropiques.

GPM was designed from its inception as an international satellite mission to unify and advance global precipitation measurements to serve the world community by providing the best possible global precipitation data for research and applications. The GPM concept is based on using combined radar/radiometer measurements on a Core Observatory as the reference standard to inter-calibrate observations from a diverse set of international instruments comprising a GPM constellation.

ISRO and CNES are implementing the Megha-Tropiques mission, which will be launched prior to 2013 and will very likely overlap with the GPM operational mission phase. The Megha-Tropiques mission will carry, among other instruments, a conical-scanning microwave radiometer (MADRAS) and a multi-channel microwave humidity sounder (SAPHIR). A

GPM partnership between NASA and ISRO/CNES will benefit these agencies in terms of data sharing, scientific collaborations on satellite inter-calibration, precipitation retrieval algorithm development, and ground validation. NASA data and scientific expertise could be valuable to ISRO during its implementation of Megha-Tropiques, especially as it pertains to the radiometer data. MADRAS and SAPHIR data would be valuable to NASA in improved sampling for GPM multi-satellite global precipitation products.

Through a NASA-JAXA launch partnership, in 2013 a GPM Core Observatory will be launched that carries both a conically-scanning radiometer, the GPM Microwave Imager (GMI), and a dual-frequency precipitation radar at 65° inclination to serve as a precipitation physics observatory and a calibration reference for all passive microwave radiometers provided by partners in the GPM mission.

## **ARTICLE 2 DEFINITIONS**

1. The “GPM mission” comprises all space and ground segment contributions provided by GPM partners, including the Core Observatory provided by NASA and JAXA, Megha-Tropiques data provided by ISRO and CNES, and Global Change Observation Mission-Water 1 (GCOM-W1) data provided by JAXA.
2. A “GPM partner” is a country or agency with a space segment (i.e., Core Observatory or constellation satellite) contribution to the international GPM effort and jointly recognized by NASA and JAXA. As the result of this Implementing Arrangement and the NASA-CNES Implementing Arrangement referenced in the Preamble of this Implementing Arrangement, ISRO and CNES shall each, individually, be a GPM partner.
3. “GPM data” consist of all standard data products: Level 1C intercalibrated radiometer data, Level 2 dual-frequency precipitation radar reflectivities, and all other Level 2 and higher GPM standard data products, as defined by the NASA-JAXA Joint Precipitation Measurement Missions (PMM) Science Team (see Article 6, Scientific Investigations).
4. “All instrument Level 1 data” are the Level 1 data from the GPM Core Observatory, GCOM-W1, and all other GPM partners’ microwave sensors.
5. A “GPM participant” is a cooperating entity of a GPM partner in the framework of GPM-related activities and is designated as such by the aforesaid GPM partner.

## **ARTICLE 3 NASA RESPONSIBILITIES**

To implement this cooperative program, NASA shall use reasonable efforts to carry out the following responsibilities:

1. Mission Data

- a. Provide access to all Tropical Rainfall Measuring Mission (TRMM) data, both near-real-time and research quality, via ftp server.
  - b. Provide access to all Level 1B radiometer data and dual-frequency precipitation radar data from the GPM mission in both near-real-time and as research products in accordance with GPM partner data policies. This includes data from all GPM partner radiometers should ISRO wish to retrieve those from NASA.
  - c. Provide access to all real-time and research products produced and/or distributed by NASA's Precipitation Processing System (PPS). These include all GPM standard data products: Level 1C inter-calibrated radiometer data, Level 2 dual-frequency precipitation radar reflectivities, and all other Level 2 and higher GPM standard data products. They also include non-standard data products generated by NASA.
  - d. Provide all PPS data through file server access to allow ISRO access to all data as it is produced.
  - e. Provide access to a theoretical basis of algorithm document for the GPM products (including brightness temperature products and precipitation products) that discusses the calibration approach, geolocation, and key aspects of the conversion from instrument counts to brightness temperature.
2. Ground Validation (GV) Data
- a. Provide access to all GPM data over Megha-Tropiques GV sites identified by ISRO.
  - b. Provide access to GV data collected by NASA and other GPM partners, subject to GPM partners' policies.
  - c. Accept ISRO participation in the GPM global GV effort, which seeks to establish error characteristics for radiometer and radar data products, validate GPM data on a global basis, and help to improve space-based precipitation algorithms.
3. Data Processing
- a. Provide a logical structure for radiometer data formatting which can be used in representing MADRAS and SAPHIR data.
  - b. Provide inter-calibrated Level 1C brightness temperatures from GPM partner radiometers and read/write tools that can be used to read or write any data from Level 1C and higher level data products.
  - c. Provide data browser tools for GPM data.
  - d. Provide HDF 5.0 formatting assistance for radiometer data.

- e. Provide GIS formatted GPM data.
  - f. Provide access to tools that help in the understanding and interpretation of GPM data.
  - g. Provide assistance in understanding, interpreting and using GPM data, on a best efforts basis.
4. Science Cooperation
- a. Accept Indian investigators to the PMM Program to become members of the NASA PMM Science Team, which comprises both U.S. and international investigators, through selection of no-cost contributions to NASA proposals.

#### **ARTICLE 4 ISRO RESPONSIBILITIES**

To implement this cooperative program, ISRO shall use reasonable efforts to carry out the following responsibilities:

- 1. Mission Data
  - a. Provide access to calibrated and geolocated Level 1B brightness temperature products from MADRAS and SAPHIR.
  - b. Provide a theoretical basis of algorithm document for the MADRAS and SAPHIR brightness temperature products that discusses the calibration approach, geolocation, and key aspects of the conversion from instrument counts to brightness temperature.
  - c. Provide access to MADRAS and SAPHIR Level 1B data as quickly as possible from the time of observation, preferably within 24 hours, for the production of standard research quality merged global radiometer products.
  - d. Provide access to MADRAS and SAPHIR Level 1B data, at a minimum on an orbital basis and with as small a transmission latency as possible, for near-real-time merged radiometer products.
- 2. Ground Validation Data
  - a. Provide access to data from ground radars and associated instrumentation (e.g., rain gauges, wind profilers, disdrometers) jointly identified by NASA and ISRO, which will be collected for Megha-Tropiques data validation and is useful for GPM satellite product evaluation and algorithm improvement.

### 3. Data Processing

- a. Provide access to ISRO rain-rate data products based on MADRAS and SAPHIR.
- b. Provide access to tools that help in understanding and interpretation of MADRAS and SAPHIR data.
- c. Provide assistance in understanding, interpreting, and using MADRAS and SAPHIR data, on a best-effort basis.

### 4. Science Cooperation

- a. Encourage participation of Indian investigators in GPM science activities conducted by the NASA Precipitation Measurement Missions (PMM) Science Team (as described in Article 6, Scientific Investigations) in satellite inter-calibration, retrieval algorithm development, ground validation, scientific research, and practical applications.
- b. Encourage submission of no-cost proposals from Indian investigators to the PMM Program to become members of the NASA PMM Science Team, which comprises both U.S. and international investigators.
- c. Accept NASA-affiliated investigators to participate in the Megha-Tropiques International Science Team (as described in Article 6, Scientific Investigations) through selection by ISRO and CNES of no-cost proposals to ISRO/CNES Megha-Tropiques Announcements of Opportunity (AOs).

## ARTICLE 5 GPM GOVERNANCE

1. ISRO shall participate in GPM mission governance through a coordinating group composed of NASA, JAXA, and other GPM partners. NASA and JAXA co-chair the group and have approved ISRO membership. The coordinating group's purpose is to provide programmatic and technical coordination among the GPM partners and to assist in establishing and enhancing GPM's global goals.

2. NASA and JAXA maintain a list of approved GPM partners and GPM participants. Notification of new GPM partners and GPM participants shall be made through the coordinating group. All decisions of the coordinating group are made by consensus of its members. The approved GPM participants have access to the same data, products, and services as the GPM partners.

## ARTICLE 6 SCIENTIFIC INVESTIGATIONS

1. To meet the science goals of the GPM program, NASA shall establish a NASA-selected PMM Science Team. NASA shall have its PMM Science Team act as an advisory body to NASA Program/Project Management for the definition and maintenance of science requirements for GPM, including the GPM algorithm development, GPM science data systems, and all NASA and standard data products for the GPM mission.

2. The NASA PMM Science Team is responsible for advising NASA Program/Project Management on the U.S. scientific requirements for GPM and the science requirements for the NASA science data system, and for the algorithm development and validation of the GPM standard products subject to the approval of the NASA-JAXA Joint PMM Science Team. (Note: The NASA-JAXA Joint PMM Science Team comprises six to seven scientists from each of the NASA and JAXA PMM Science Teams, selected by the respective Program Scientists.) The NASA PMM Science Team is also responsible for monitoring the development of the GMI and reporting issues that affect science to the NASA-JAXA Joint PMM Science Team. The NASA PMM Science Team collects and analyzes ground-based measurements in the U.S. and elsewhere in collaboration with international GPM ground validation partners to evaluate GPM satellite data products. The NASA PMM Science Team consults with the JAXA PMM Science Team regarding any changes in the measurement requirements for GPM. The NASA PMM Science Team responds, within an appropriate time, to requests for consultation from the JAXA PMM Science Team.

3. To enhance the scientific analysis and the science benefits of the Megha-Tropiques program, ISRO shall establish with CNES an ISRO/CNES-selected Megha-Tropiques International Science Team. For that, the initial ISRO/CNES Megha-Tropiques Joint Science Working Group will be complemented by International Principal Investigators selected by ISRO/CNES after no-cost proposals to the ISRO/CNES Megha-Tropiques Announcements of Opportunity (AOs). The role of the Megha-Tropiques International Science Team is to advise the ISRO/CNES program/project management and to contribute to:

- a. The development of Megha-Tropiques retrieval algorithms and calibration/validation experiments;
- b. The basic research on the physics of the tropical climate;
- c. Synergistic studies using multisensor/multisatellite data to understand convective processes; and
- d. The development of techniques for assimilation of Megha-Tropiques radiances or derived geophysical parameters in numerical models.



## ARTICLE 7 POINTS OF CONTACT

The NASA-designated point of contact is:

The programmatic designated point of contact is:

Steven Neeck  
Science Mission Directorate  
NASA Headquarters  
300 E Street, SW - Mail Suite 3B74  
Washington, D.C. 20546 USA  
E-mail: [steven.neeck@nasa.gov](mailto:steven.neeck@nasa.gov)  
Telephone: +1-202-358-0830  
Facsimile: +1-202-358-2770

The ISRO-designated point of contact is:

The programmatic designated point of contact is:

Scientific Secretary, ISRO  
Indian Space Research Organisation HQ  
Antariksh Bhavan,  
New BEL Road  
Bangalore 560 094  
E-mail: [scientificsecretary@isro.gov.in](mailto:scientificsecretary@isro.gov.in)  
Telephone: +91-80-23416356  
Facsimile: +91-80-23415298

## ARTICLE 8 DATA DISTRIBUTION

1. The Parties will encourage each GPM partner to make instrument Level 1 data available to all of the GPM partners consistent with their respective data distribution policies.

a. All instrument Level 1 data shall be made available as soon as the initial on-orbit calibration and validation are completed.

b. No additional latency aside from download, processing, and network access shall be added to the time at which GPM partners can use all instrument Level 1 data.

c. GPM data and all instrument Level 1 data shall be available to users for research, operational, applications, and outreach purposes, consistent with the Parties' data distribution policies. For purposes other than these, the specified data shall be made available in accordance with terms and conditions to be established by the Party that provides the instrument and data.

d. NASA agrees to the right of ISRO to redistribute GMI Level 1B radiometer data and GPM data to other GPM partners and participants. In addition, ISRO may redistribute other GPM partners' instrument Level 1 data in accordance with the aforesaid partners' data policies. ISRO agrees to the right of NASA to redistribute Level 1B brightness temperature products from MADRAS and SAPHIR to other GPM partners and participants.

2. The analyzed results from GPM data shall be made available to the general scientific community through publication in appropriate journals or presentations at scientific conferences as soon as possible and consistent with standard scientific practices. Such publications shall credit the NASA-JAXA GPM project and the approved GPM partners. In the event that reports or publications are copyrighted, all approved GPM partners shall be granted a royalty-free right under the copyright to reproduce, use, and distribute such copyrighted work for their purposes by the copyright holder.

## **ARTICLE 9 OWNERSHIP OF EQUIPMENT**

Equipment provided by NASA pursuant to this Implementing Arrangement shall remain the property of NASA. Equipment provided by ISRO pursuant to this Implementing Arrangement shall remain the property of ISRO. Each Implementing Agency agrees to return the other Implementing Agency's equipment in its possession at the conclusion of the project.

## **ARTICLE 10 RELATIONSHIP TO THE FRAMEWORK AGREEMENT**

This Implementing Arrangement, concluded pursuant to Article 4 of the Framework Agreement, incorporates by reference and is subject to the terms and conditions of the Framework Agreement. In the event of a conflict between the provisions of this Implementing Arrangement and the Framework Agreement, the terms of the Framework Agreement shall govern.

## **ARTICLE 11 AMENDMENTS**

This Implementing Arrangement may be amended through mutual written agreement by the Parties.

**ARTICLE 12**  
**ENTRY INTO FORCE AND DURATION**

This Implementing Arrangement shall enter into force upon the last date of signature and shall remain in force until December 31, 2016, unless terminated by one Party providing at least ninety (90) days' advance written notice to the other Party of its intent to terminate.

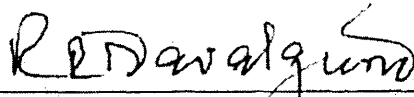
DONE in two originals at AUMEDABAD Washington, DC, on the 20<sup>th</sup>/26<sup>th</sup> day of March, 2012, in the English language.

FOR THE NATIONAL AERONAUTICS  
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